Diamagnetic levitation of solid powder by permanent magnets

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Diamagnetic materials can be levitated in a static environment at room temperature without external stimulation using diamagnetic magnetic levitation technology. This technology is also interesting as an alternative technology for space experiments. It has been known in theory for decades, however, it was experimentally proven about 30 years ago. The main reason for the difficulty of the experiment is that the magnetic susceptibility of diamagnetic materials is very small. Usually, to realize the diamagnetic magnetic levitation state, a huge magnet such as a hybrid superconducting magnet is required to generate an extremely strong magnetic field. Recently, we performed a precise simulation of the magnetic field distribution in a state in which multiple permanent magnets were arranged in a specific arrangement, and succeeded in realizing diamagnetic magnetic levitation of water, alumina, etc. In this paper, we report the successful levitation of NaCl powder, a solid material, by diamagnetic magnetic levitation technology. Since NaCl is water-soluble, it can also be applied to a fundamental scientific experiment like crystal precipitation from a NaCl supersaturated aqueous solution that levitates without a container.

The magnets used in this study are a pair of small neodymium magnets with a depth of 5 mm, a width of 1 mm, and a height of 10 mm (magnet type A, Figure 1), and a pair of cylindrical magnets with a diameter of 1 mm and a length of 3 mm (magnet type B, Figure 1). These magnets were fixed inside of a transparent acrylic case, and the sodium chloride powder blown out from a plastic container was gently introduced into the acrylic case through a flexible silicone tube. The sodium chloride powder settled very slowly got together into the potential minimum generated in the gap between the two pairs of magnets. (Figure 2). The sodium chloride powder remained magnetically levitated for over 4 days.

So far, the magnetic levitation of solid inorganic compounds has been rarely reported even with superconducting magnets, however, our experiments revealed that detailed investigation of a magnetic field makes magnetic levitation much easier. Our technique can be applied to the development of microscopic spherical lenses or study of thermodynamic phenomena like crystallization of an ionic material which is dissolved in water levitating in a magnetic field without any container.

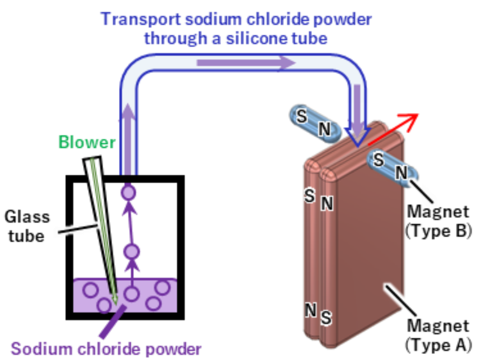

Fig. 1 Experimental set up

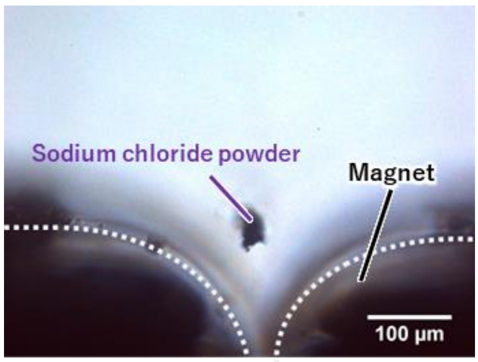

Fig. 2 Levitating sodium chloride powder